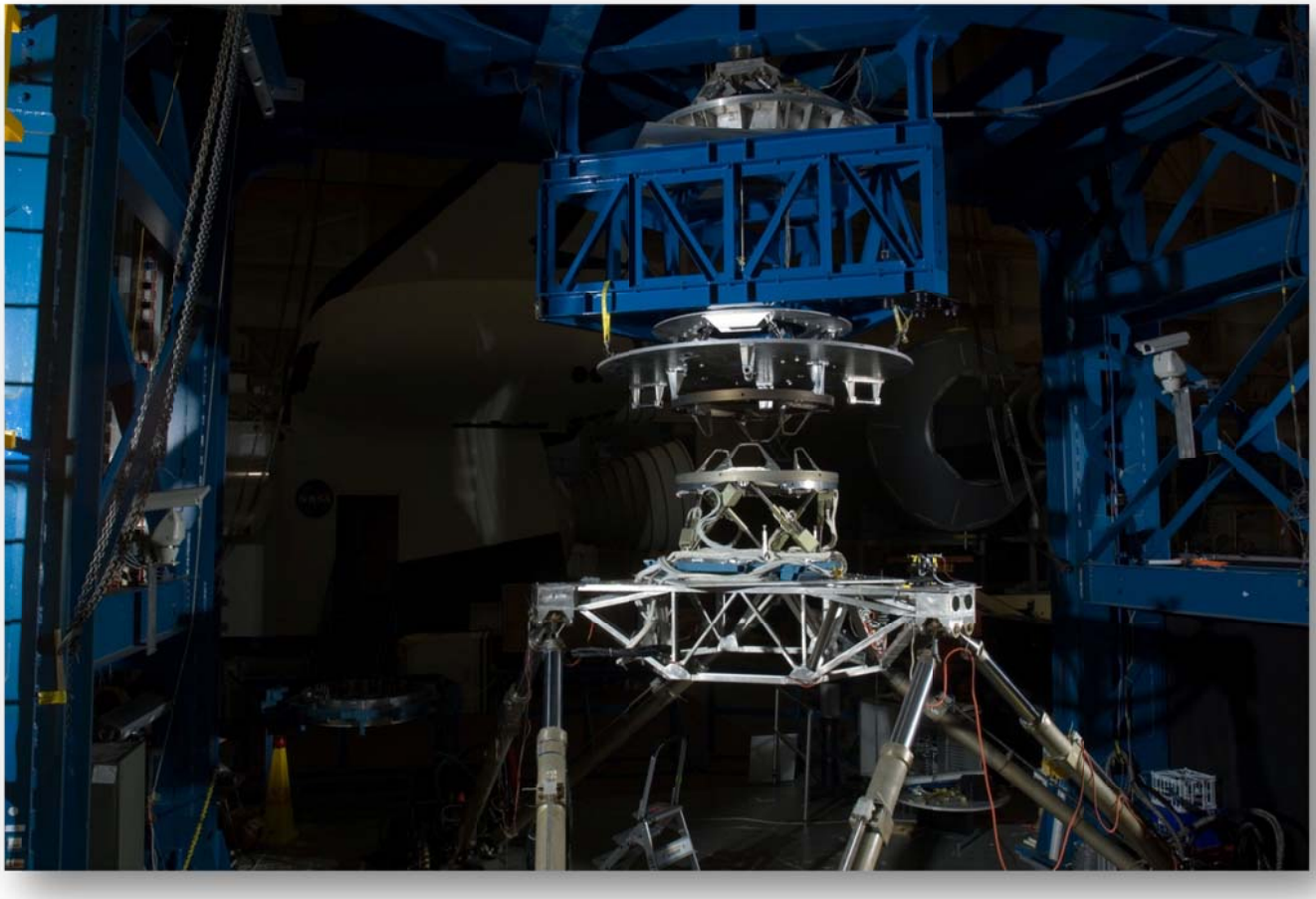
Abstract – Six-Degree-of-Freedom Dynamic Test System (SDTS) User Test Planning Guide

Test process, milestones and inputs are unknowns to first-time users of the SDTS. The User Test Planning Guide aids in establishing expectations for both NASA and non-NASA facility customers. The potential audience for this guide includes both internal and commercial spaceflight hardware/software developers. It is intended to assist their test engineering personnel in test planning and execution. Material covered includes a roadmap of the test process, roles and responsibilities of facility and user, major milestones, facility capabilities, and inputs required by the facility. Samples of deliverables, test article interfaces, and inputs necessary to define test scope, cost, and schedule are included as an appendix to the guide.

Six-Degree-of-Freedom Dynamic Test System (SDTS)

User Test Planning Guide



National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77058

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1.0 Introduction

The Johnson Space Center (JSC) has created and refined innovative analysis, design, development, and testing techniques that have been demonstrated in all phases of spaceflight. JSC is uniquely positioned to apply this expertise to components, systems, and vehicles that operate in remote or harsh environments. We offer a highly skilled workforce, unique facilities, flexible project management, and a proven management system.

1.1 Purpose

The purpose of this guide is to acquaint Requesters with the requirements for test, analysis, or simulation services at JSC. The guide includes facility services and capabilities, inputs required by the facility, major milestones, a roadmap of the facility's process, and roles and responsibilities of the facility and the Requester. Samples of deliverables, facility interfaces, and inputs necessary to define the cost and schedule are included as appendices to the guide.

1.2 Facility Availability

JSC facilities are available for the National Aeronautics and Space Administration (NASA), other government agencies, and commercial requesters. We have developed user-friendly agreements to streamline business relationships and are eager to share our unique facilities and expertise. We invite your inquiries regarding application or adaptation of our capabilities to satisfy your special requirements. Briefings on general or specific subjects of mutual interest can be arranged at JSC or at your business site.

1.3 Inquiries

General inquiries regarding the use of JSC facilities should be directed to:

JSC Engineering Directorate
Johnson Space Center
2101 NASA Parkway, Houston, TX 77058
Phone: 281-483-8991
E-mail: jsc-ea-partnerships@mail.nasa.gov

Inquiries regarding the Six-Degree-of-Freedom Test System (SDTS) should be directed to:

LeBarian Stokes
SDTS Laboratory Manager
Johnson Space Center
2101 NASA Parkway, Houston, TX 77058
Phone: 281-483-8965
E-mail: lebarian.stokes-1@nasa.gov

Please refer to the Engineering Services Web site, http://jsceng.nasa.gov, for additional information and general inquiries about test, analysis, and simulation capabilities at JSC.

1.4 Six-Degree-of-Freedom Dynamic Test System

The Six-Degree-of-Freedom Dynamic Test System (SDTS) is a real-time, six-degree-of-freedom, short-range simulator with a motion base designed to simulate the relative dynamics of two bodies in space mating together (i.e., docking or berthing). The SDTS has the capability to test full-scale docking and berthing systems. Its features include the following:

- Repositionable, stationary upper platform
- Motion base that is a hydraulic-powered Stewart platform, capable of supporting a 3,500 lb payload

Simulations are controlled by interconnected computers running real-time simulation software. The motion base also can be used for non-mating applications (e.g., docking sensors, instruments). The SDTS provides a superstructure for mounting test articles, test sensors, an intercom network for voice communications, and a synchronized timing system for data acquisition. In addition, the facility provides two different dynamic and kinetic simulations to control the table—a two-free-body docking simulation and a Space Station Remote Manipulator System (SSRMS) berthing simulation. The SSRMS includes Orbital Boom Sensor System (OBSS) dynamics.

Services Provided

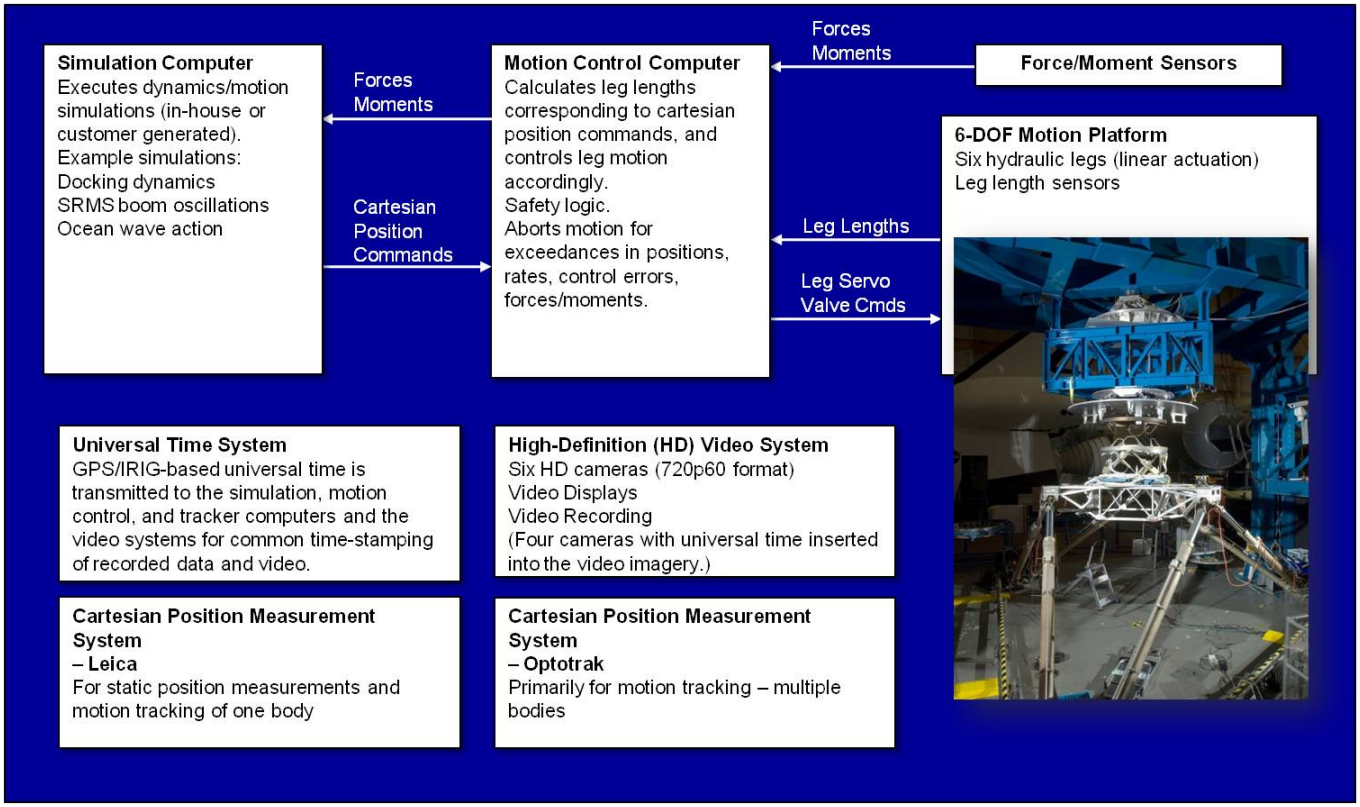
• Real-time, six-degree-of-freedom short-range motion-based simulation
• Closed-loop testing of automated docking systems
  − Testing of mating interfaces, including contact forces
  − Docking and undocking operations
  − Assembly of space structures using berthing and docking
• Engineering evaluation of mechanical device operation
• Verification of in-space assembly tasks
• Development of crew training and operational procedures
• Demonstration of advanced robotics technologies

1.5 SDTS Facility Specifications

Parameter	Value
Payload capacity	3,500 lbm
Lateral motion range (average)	±40 in.
Lateral motion range (peak)	±62 in.
Vertical motion range (maximum)	124 in.
Angular motion range	±20°
Data channels available (analog)	96
Motion table bandwidth (typical)	8 Hz
Inner control loop (DCS) (typical)	800 Hz
Outer control loop (SimHost) (typical)	200 Hz
Average pose accuracy	0.04 in., 0.03 deg.
Incremental accuracy (typical)	0.006 in.
Average pose accuracy	0.06 in., 0.07 deg.
Horizontal roller assembly (five positions)	16, 20, 26, 30, 31 feet tall

2.0 Facility Layout

SDTS Equipment Configuration*



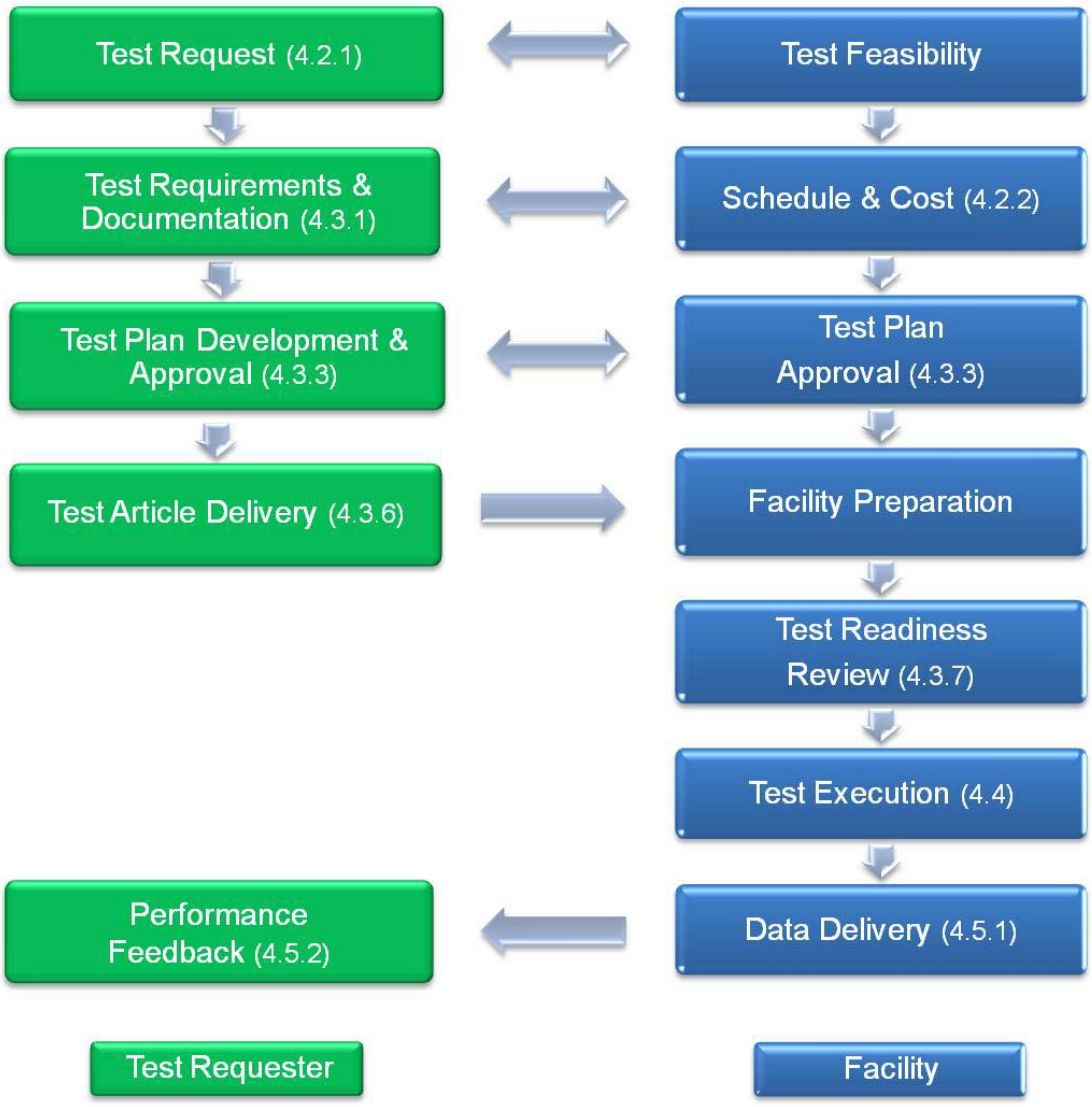
* See Appendix A for facility interfaces and sample test configurations.

3.0 Safety and Health

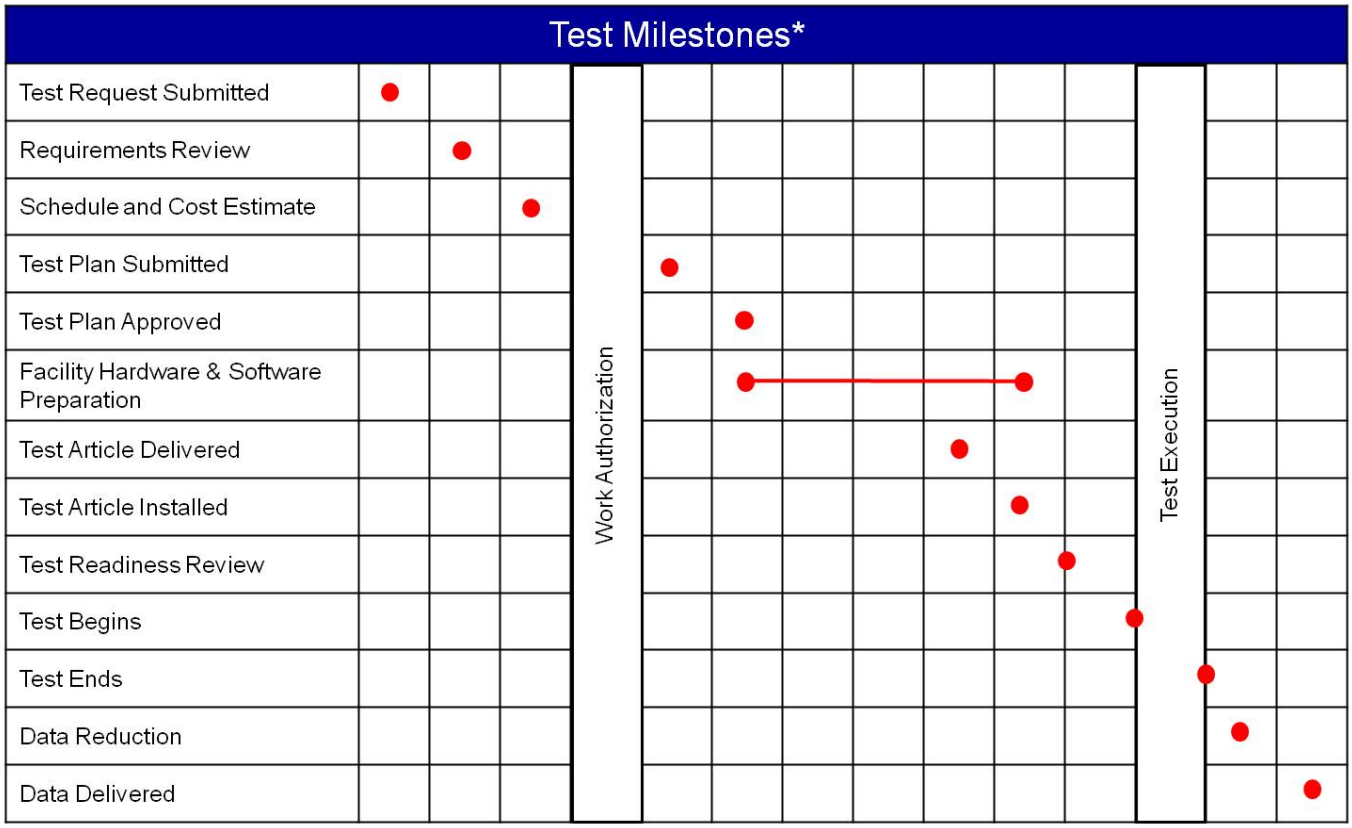
Safety is an integral part of the culture at NASA. Management, leadership, and employee involvement from all organizations are critical to the success of NASA's safety program. In order to ensure personal safety and a safe test environment throughout the process, the Requester shall furnish the facility with the information necessary to perform a hazard assessment of the test article. Additionally, while visiting JSC, the Requester shall follow all facility-specific safety and health requirements. A facility safety briefing shall be provided to all personnel prior to the start of the test. The safety briefing will include a review of the SDTS safety rules, potential hazards, and emergency procedures.

4.0 Test Process Flow

The flowchart presented below outlines the basic roadmap and significant milestones between the initial test request and delivery of test data. The flow is separated between Test Requester actions and Facility actions, highlighting interactions and inputs between the Test Requester and the facility Test Director.



The test schedule is highly dependent on the complexity of the test, facility availability, and sequence of runs. A detailed schedule shall be developed following a review of the test objectives and requirements. For time-critical testing, this schedule may be accelerated. Major milestones are presented below:



* A test schedule template is included in Appendix D.

4.1 Export Controlled and Proprietary Information

The SDTS provides for protection of export controlled and proprietary information and hardware throughout the test process. The Test Requester shall clearly mark all export controlled or proprietary hardware items and data provided with a notice of restriction on disclosure or usage. The Test Director shall safeguard export controlled or proprietary items from unauthorized use and disclosure and ensure that test articles remain secure within the facility and are properly sequestered. Hardware items shall be returned to the Test Requester or disposed of in accordance with the Test Requester's instructions at the completion of the test activity.

4.2 Test Initiation Phase

The test initiation phase establishes the relationship between the Test Requester and the SDTS Manager. The Test Requester shall provide a test request to the SDTS Manager, which will be used to determine test feasibility and to develop a cost estimate and a preliminary test schedule. An initial requirements review shall define the characteristics of the test article, test objectives, and special considerations for the test. An onsite tour of the facility is highly recommended for familiarization and to provide an opportunity for an exchange of technical information.

Inputs: Test Requester provides test request, identifies Test Article Expert

Activities: SDTS Manager reviews test request to determine test feasibility

Outputs: Facility provides estimated cost and schedule to Test Requester. Test Requester develops test plan. Test facility provides assistance as needed.

4.2.1 Test Request

The test request outlines the test objectives, test article description, and schedule. A Test Request Worksheet is provided in Appendix B. This worksheet addresses the basic requirements for testing in the SDTS. It is suggested that the Test Requester complete this worksheet to facilitate the development of a preliminary test plan. Contact the SDTS Manager if you have questions about completing the Test Request Worksheet. At a minimum, the test request should include the following information:

Test Objective

A brief description of the test requirements, including, but not limited to, the following:

- Desired test conditions
- Proposed test approach
- Test data requirements

Test Article Description

A brief description of the test article, including, but not limited to, the following:

- Size (provide drawings, sketches, photos)
- Weight
- Test article interface (e.g.,load points, method of suspension or test article support)
- Test article interface requirements
- Orientation
- Handling and storage requirements

Schedule

Identify the required start date and proposed date for test completion.

4.2.2 Schedule, Cost Estimate, and Funding

A cost and schedule estimate, including major milestones, will be delivered to the Test Requester following receipt of the Test Request Worksheet.

The cost estimate is completed and provided to the Test Requester who determines if it is acceptable. Once it is approved, the Test Requester initiates the funding transfer to the SDTS organization. The Requester's organizational budget analyst contacts the budget analyst of the Software, Robotics, and Simulation Division (SRSD) to facilitate the transfer of funds for the test. After the funds have been received by the SRSD, the SDTS initiates test preparation. An Internal Task Agreement (ITA) also can be used to transfer funds to the SDTS organization (SRSD) if the Requester's organization is one of the JSC program offices that utilize ITAs, such as the International Space Station Program. If the Requester is a non-government entity, a Space Act Agreement is usually set up with the non-government partner to identify the NASA resources to be utilized and to provide a reimbursable formal agreement between NASA and the non-government partner.

4.3 Test Preparation Phase

The detailed test plan, test schedule, and test article interface are finalized during the test preparation phase. The Test Requester shall provide detailed test requirements and test article documentation to the SDTS Manager. A Test Readiness Review (TRR) will be held following approval of the test plan.

Inputs:	Test Requester provides test requirements, test plan, and test article documentation
Activities:	Facility reviews test plan, begins assembly of facility interface/support structure(s)
	Test Requester ships/transports test article to JSC
Outputs:	Test Requester and SDTS Manager approve test plan and test schedule
	Facility holds TRR

4.3.1 Test Requirements

A complete understanding of test requirements is mandatory for a successful test. Test requirements must be defined and reviewed so that the test team understands the effect of the requirements on test facility preparation. The Test Requester shall provide a detailed list of test requirements, including, but not limited to, the following:

- Test simulation requirements
- Interface requirements (e.g., structural, electrical, mechanical)
- Data/instrumentation requirements (provided by Test Requester and facility)

4.3.2 Test Article Documentation

Test Article Drawings

The Test Requester shall provide detailed test article drawings as requested by the facility. Test article drawings are used to prepare the facility interfaces, test article support structures, and instrumentation connection points.

Test Article Hazard Identification

The safety of facility personnel, facility equipment, and the test article is imperative to NASA. Potential hazards, material compatibility, and facility interfaces will be reviewed with the facility prior to testing. In certain instances, special precautions must be taken, due to the severity level of these potential hazards. The Test Requester may be asked to provide further information to clarify or mitigate a potential hazard. It is highly recommended that the Test Requester provide a test article hazard analysis or complete the Test Article Hazard Checklist included in Appendix B. The analysis should consider test article handling, support equipment, potential failure modes during the test, hazardous materials, batteries, high-voltage/current devices, pressurized components, dangerous mechanical devices, sharp edges, and any other potential hazards.

4.3.3 Test Plan

A test plan shall be developed by the Test Requester. The test facility can provide assistance as needed. A test plan is necessary to ensure that all requirements of the Test Requester and the facility are achieved in an efficient and reproducible manner. The test plan is instrumental in developing the detailed test procedure. The final test plan shall be approved by the Test Requester and the facility. The test plan will be the controlling document, with respect to scope and approach for the test program. The test plan will include, at a minimum, the test objectives, scope, test article description, safety considerations, and data requirements. Changes to the test plan that occur after the TRR that result in a major change to the scope of the test or that present new hazards may require a delta TRR. A sample test plan is included in Appendix D.

4.3.4 Test Schedule

A detailed schedule shall be developed by the SDTS Manager and approved by the Test Requester. The schedule shall allow adequate time for review and approval of test requirements, assembly of facility interfaces/structures, and delivery of the test article. The schedule of other tests and maintenance activities will be reviewed, and potential conflicts shall be addressed by the Test Director.

4.3.6 Test Article Delivery

The test article delivery date will be determined on a case-by-case basis. An agreed-upon delivery date shall be captured as a milestone in the test schedule. The Test Requester shall provide detailed handling instructions prior to delivery of the test article, including handling

hazards, cleanliness, and storage requirements. An inspection of the test article shall be performed by the facility and the Test Article Expert prior to the start of testing. NASA encourages Test Article Expert participation in the test article integration phase to provide immediate feedback on test article handling and any integration issues that arise.

4.3.7 Test Readiness Review

A TRR will be held to ensure the completion of all necessary facility and test article activities prior to test execution. The TRR will include the following:

- Review of the test plan, test procedures, and other required test documentation
- Confirmation of facility and test article readiness
- Review of configuration records, including facility interface control documents, instrumentation calibration, and software configuration
- Assurance that controls are in place to mitigate risks or hazards identified in the Test Article Hazard Analysis
- Verification that data acquisition and processing functions are in place to adequately capture all critical data
- Confirmation that multimedia coverage is adequate to provide recognition and assessment of potential test anomalies

Approval to proceed with test operations is granted by the Test Readiness Review Board (TRRB). The Test Director shall ensure that all TRR actions have been accomplished prior to the start of the test. The TRRB shall convene 1 to 5 business days prior to the start of the test. TRRB participants shall include the following:

NASA TRRB Chairman	Test Article Expert (Appointed by Test Requester)
Test Director	SDTS Manager
NASA Test Safety Officer	Quality Engineer (as required)

4.4 Test Execution Phase

NASA encourages Test Requester participation in the testing activity. The Test Requester shall provide a Test Article Expert to verify that test setup and execution meet the stated objectives. The Test Article Expert also shall verify test article performance and approve requested test deviations during test operations.

Inputs:	Approval to begin testing received from TRRB
Activities:	Facility completes facility buildup, detailed test procedure
	Facility conducts testing activity
Outputs:	Test completed

4.4.1 Test Authority

The Test Director has the authority and responsibility to direct the test in accordance with the approved test plan and to terminate test activities per test rules when danger is imminent or test control cannot be maintained. The Test Director will ensure that positive actions are taken to halt any steps in the test procedure whenever unsafe or hazardous test conditions arise. The Test Director, with the concurrence of the Test Article Expert, has the authority to terminate the test when sufficient data has been obtained to meet objectives or when objectives cannot be met. Test team personnel will accept directions only from the Test Director.

4.4.2 Quality Assurance

Quality Assurance has the responsibility to verify that the test facility is ready for the test by ensuring that all constraints to the test have been closed. For testing of controlled hardware, Quality Assurance is available to verify that the test article successfully passes all functional acceptance, qualification, or certification requirements. Quality Assurance will prepare a discrepancy report or a material review record to document a nonconformance if the test article or equipment fails or deviates from specified limits. Quality Assurance also is available to monitor qualification and certification tests to ensure that approved test plans and procedures are used, equipment records are maintained, test tools are within calibration, inspection checkpoints are completed, and nonconformances are documented. Consult with the SDTS Manager to determine the level of Quality Assurance support required for the test.

4.4.3 Test Deviations

Changes to the test procedure shall be approved by the Test Article Expert with concurrence from the Test Director. Deviations that result in a major change to the scope of the test or that present new hazards may require a delta TRR.

4.4.4 Facility Equipment

The facility equipment is meant for use by JSC personnel. Prior arrangements shall be made with the SDTS Manager for potential use of this equipment by the Test Requester. The duration and type of use will be identified prior to authorization for use. JSC workstations are not available for use by Test Requester personnel. This is necessary to protect the integrity of the facility. The Test Requester shall make prior arrangements with the SDTS Manager if a dedicated workstation is required during testing. The Test Requester is encouraged to bring a laptop for use during the test. Wireless Internet access is available in the facility.

4.5 Test Closeout Phase

Data shall be delivered to the Test Requester within 10 business days following completion of testing. The Test Requester shall notify the SDTS Manager upon receipt of the data. Acceptance of the test data concludes the test activity.

Inputs:	Test completed
Activities:	Facility ships/transports test article to Test Requester
	Facility delivers data to Test Requester
Outputs:	Test Requester accepts data
	Test Requester completes Customer Feedback form

4.5.1 Test Report

A test report is an assembly of test results. The format of the test report is normally specified by the Test Requester and is prepared by the Test Requester or the facility. The standard test report format includes a description of the test and objectives, test observations, test results, and data plots.

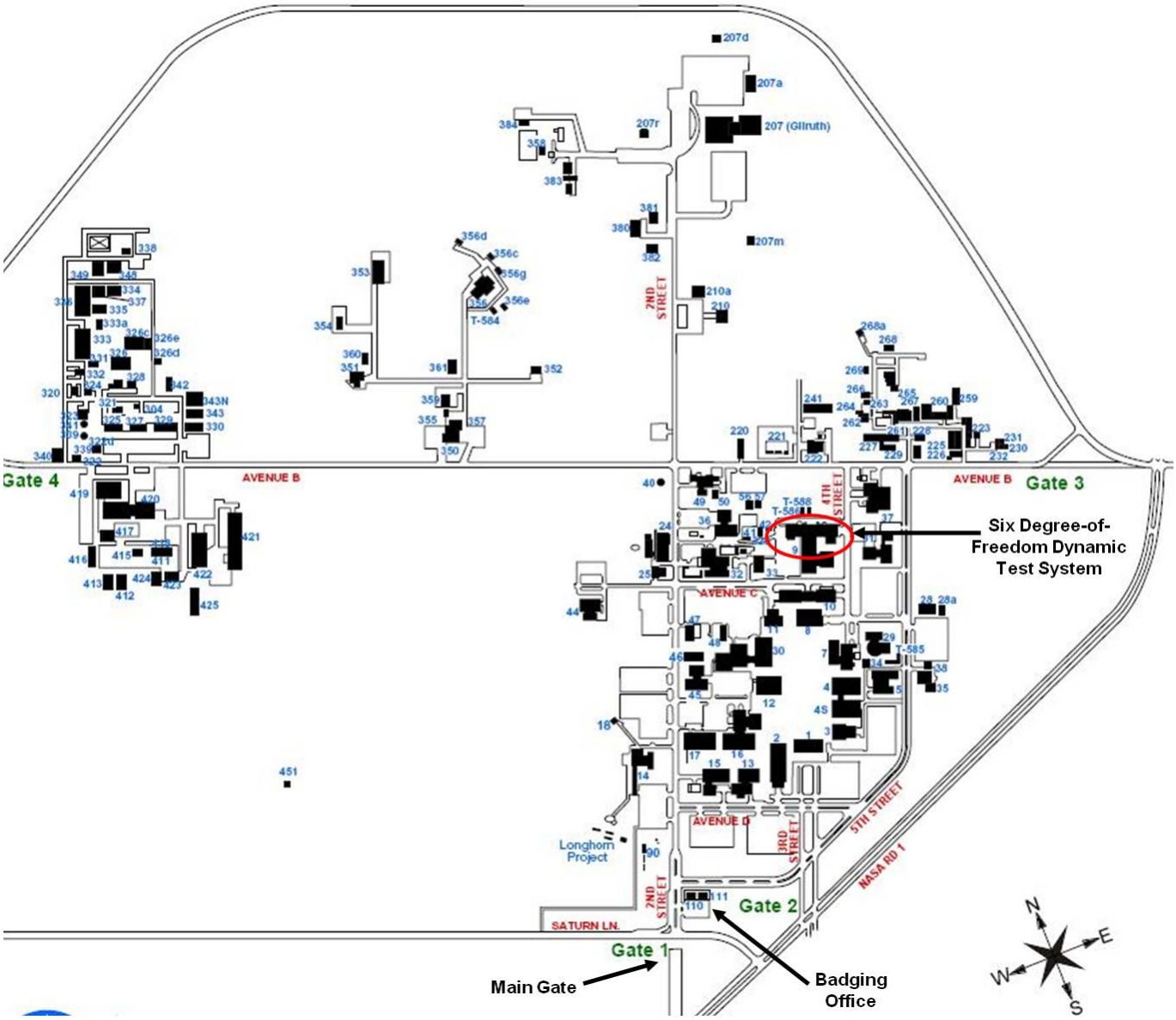
4.5.2 Customer Feedback

The SDTS requests feedback from our customers. Evaluation of the services we provide enables continued improvement to our process. A Customer Feedback form is included in Appendix E. You are encouraged to complete this form and return it to the SDTS Manager, following receipt of the test data. Your feedback is greatly appreciated.

5.0 Facility Access

Identification badges are required for all persons requiring access to JSC. The SDTS Manager or designee will initiate a badge request for all Test Requester personnel who will be participating in the test activity. Badge requests must be submitted at least 4 days prior to the visit to prevent badge processing delays. Badge requests for non-U.S. citizens may require a minimum of 30 business days to process. Test Requester personnel shall arrive at JSC Building 110 to pick up temporary identification badges. Visitors to JSC must show a current picture identification (valid driver's license, U.S. passport, government ID card).

The SDTS is located in JSC Building 9 North. The facility is restricted to authorized personnel. Test Requester personnel who will be participating in the test activity must be escorted at all times.



6.0 Roles and Responsibilities

SDTS Manager – Responsible for supplying the test product. The SDTS Manager coordinates and communicates with the Test Requester to define test requirements, cost, and schedule.

Test Director – Responsible for performance of the test. The Test Director leads the testing activities, ensuring that procedures are carried out per the SDTS requirements.

Test Requester – The client requesting performance of a test activity. The Test Requester is responsible for the test article and for providing a Test Article Expert.

Test Article Expert – A representative of the Test Requester with thorough knowledge of the test article and how it is to be operated in the test environment. The Test Article Expert also is responsible for approving the test plan and verifying that test objectives are met.

Test Safety Officer – Reviews the test article hazard assessment and prepares an integrated hazard analysis for the test facility to identify any additional hazards that could result from mating the test article to the test facility.

Quality Engineer – Responsible for verifying that the test facility is ready for the test by ensuring that all constraints to the test have been closed.

Responsibilities Matrix

Item	Test Requester	Facility
Test Request Worksheet	Create	Review and provide assistance as needed
Cost and schedule	Approve	Create and approve
Hazards	Identify test article hazards	Create test article/facility integrated hazard analysis
Test plan	Develop and approve	Assist, review, and approve
Detailed test procedure	Review	Develop and approve
Facility hardware and software setup		Complete
Test article and related equipment	Delivery, checkout, interface, operation, and handling	Mate to test fixture/interface
Test Readiness Review	Approve	Conduct and approve
Test execution	Verify test article performance Verify that test setup and execution meet objectives Approve requested deviations	Execute test Review and approve requested deviations
Test data/results	Notify Test Director of data receipt and approval	Deliver to Test Requester
Removal of test article	Remove from facility or provide instruction	Execute per request

Acronyms

°C	degrees Celsius
°F	degrees Fahrenheit
3-D	three-dimensional
6-D	six-dimensional
ASCII	American Standard Code for Information Interchange
Cmds	Commands
dBA	decibel A-weighting
DCS	Digital Control System
DOF	Degree of Freedom
EDU	Engineering Development Unit
ft	feet
FTP	File Transfer Protocol
GNC	Guidance, Navigation, and Control
GPS	Global Positioning System
H	Height
HD	High Definition
HDVS	High-Definition Video System
hr	hour(s)
Hz	Hertz
in.	inch(es)
IRIG	Inter-Range Instrumentation Group
ITA	Internal Task Agreement
JSC	Johnson Space Center
L	Length
lb	pound(s)
lbm	pound-mass
LIDS	Low Impact Docking System
m	meter(s)
mm	millimeter(s)
NASA	National Aeronautics and Space Administration

OBSS	Orbital Boom Sensor System
SDTS	Six-Degree-of-Freedom Dynamic Test System
SRSD	Software, Robotics, and Simulation Division
SSRMS	Space Station Remote Manipulator System
TD	Test Director
TRR	Test Readiness Review
TRRB	Test Readiness Review Board
W	Width

Appendices

A. Facility Interfaces and Sample Test Configurations

B. Test Request Worksheet

C. Instrumentation Provided by Facility

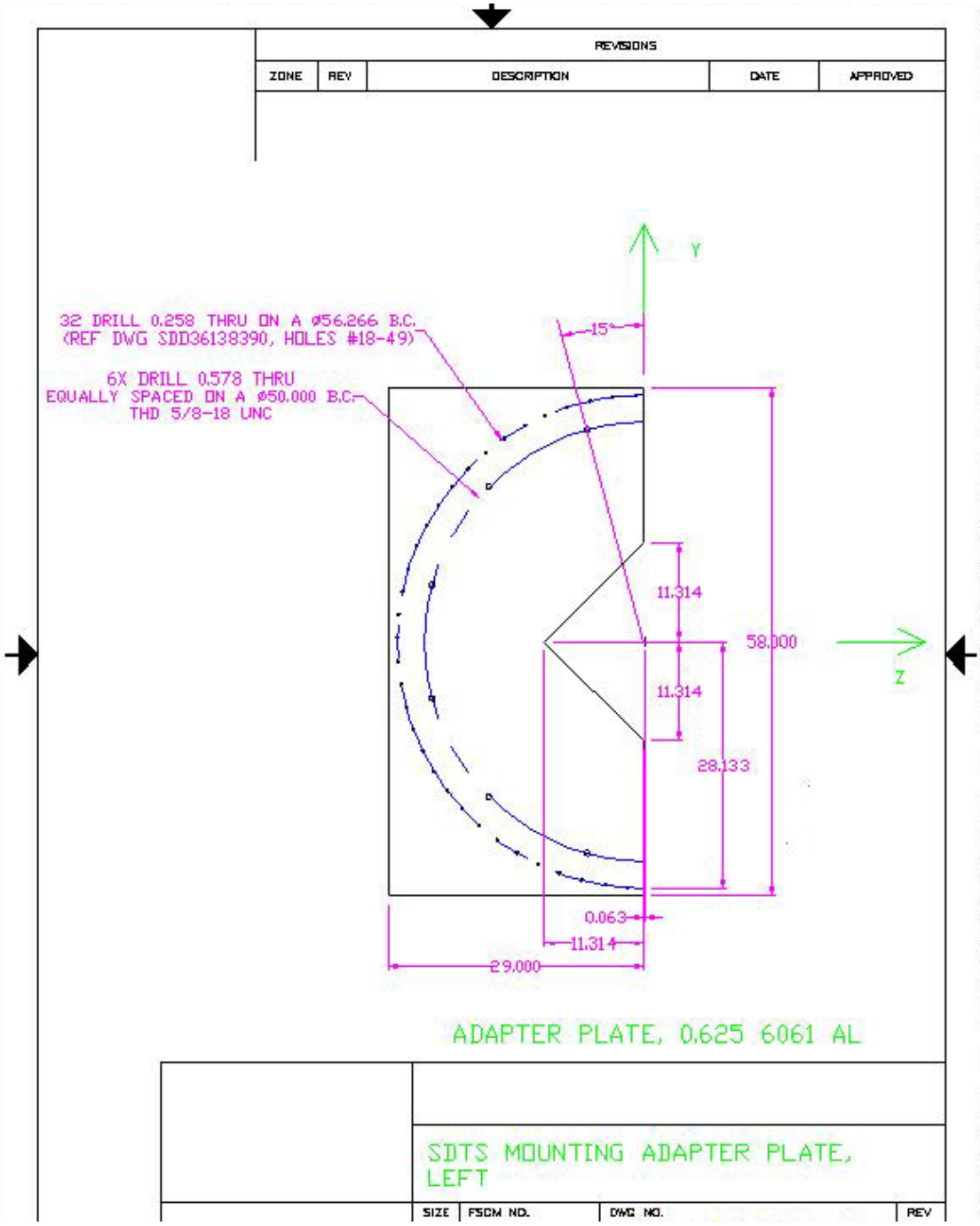
D. Sample Test Plan

E. Customer Feedback

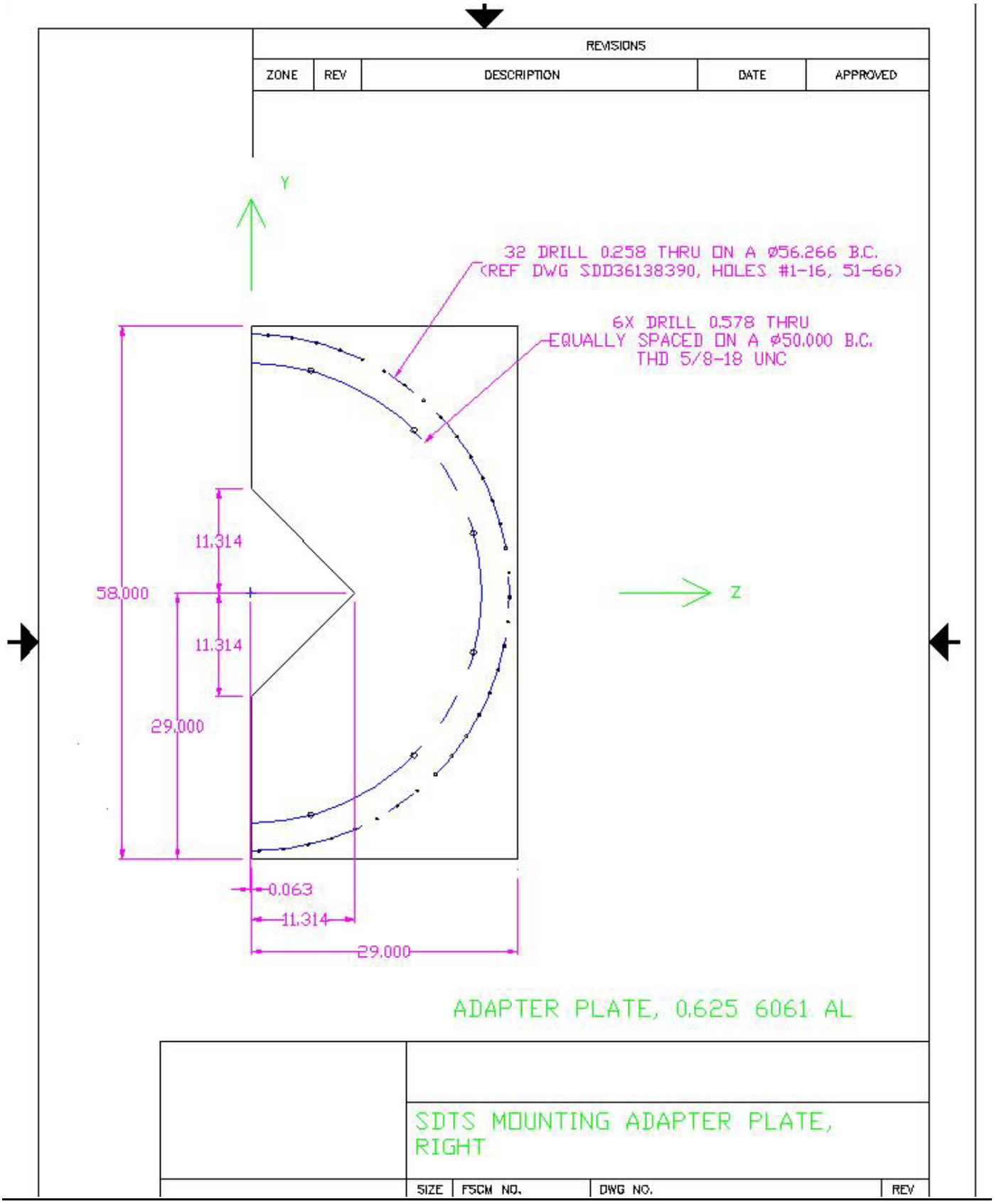
Appendix A Facility Interfaces and Sample Test Configurations

The test fixture drawings included in this guide are a sampling of the capabilities within the SDTS. The facility maintains a variety of fixtures to support general and requester-specific testing. Additional test fixtures are available upon request. The facility also can manufacture test fixtures to requester specifications. Contact the SDTS Manager to discuss test article interface requirements.

SDTS Mounting Adapter Plate – Left



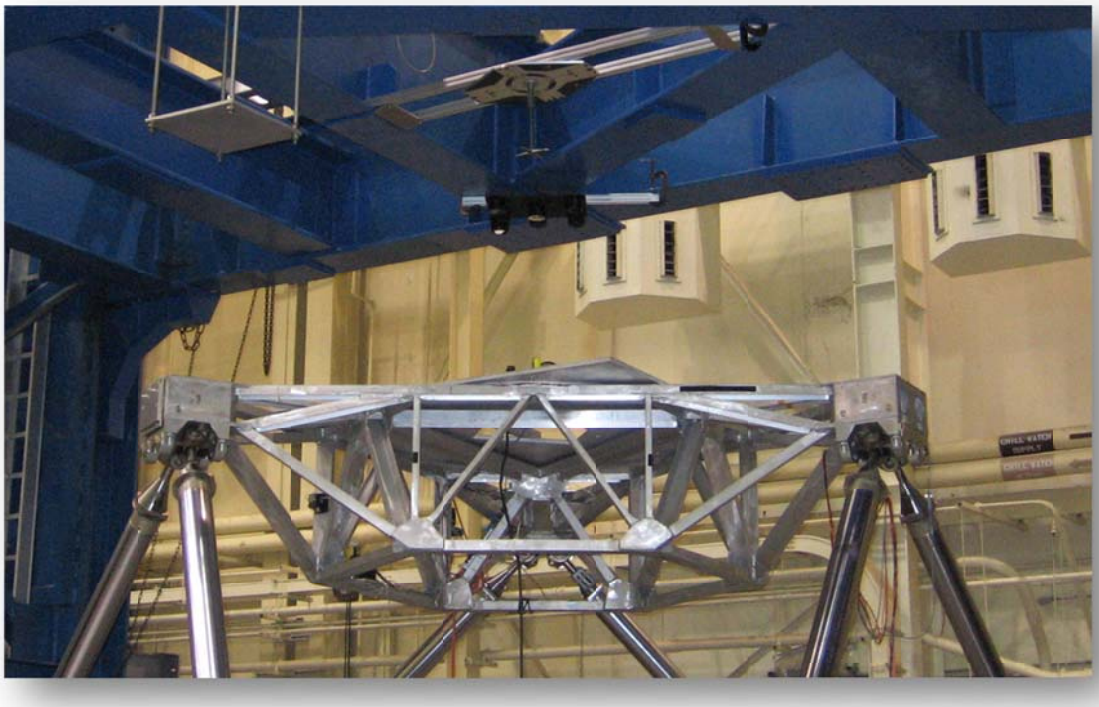
SDTS Mounting Adapter Plate – Right

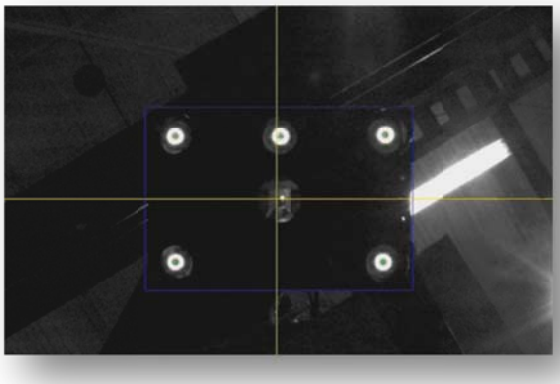


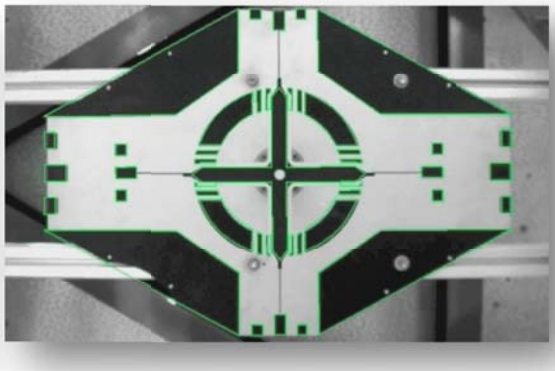
Sample Test Configurations

Pathfinder Docking Sensors and Navigation Software Testing

- Demonstrated real-time navigation software in a real-time environment
- Installed and evaluated two pathfinder sensor systems on the SDTS motion table
- Implemented closed-loop sensors with Guidance, Navigation, and Control (GNC) algorithms running real-time

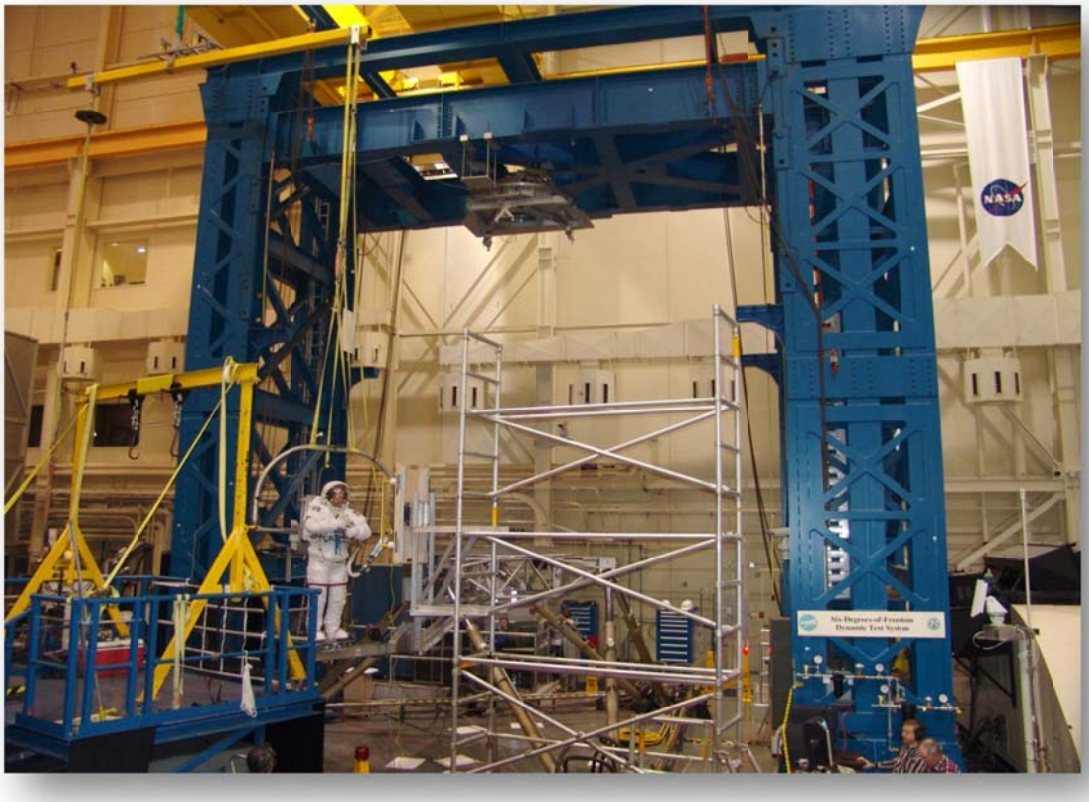






Low Impact Docking System (LIDS) Engineering Development Unit (EDU) Testing

SDTS Extravehicular Activity Trainer



Appendix B Test Request Worksheet

Test Requester Information

Test Article Expert:	Contact Information (Phone, E-mail, Address):

Test Objectives

Purpose of Test:	
Proposed Test Start Date:	Critical Test Start Date:

Test Article

Test Article Description:	
Physical Dimensions (L/W/H):	Weight:

Operational Requirements

Functional Checks (Describe any functional checks to be performed prior to, during, or after testing):	
Continuous Operations (24 hr):	Authorized Shutdown Points:

Test Article Handling Requirements

Cleanliness Level:	Controlled Access:
Special Moving/Handling:	
Storage Requirements:	

Test Article Interface

Test Article Interface Design (Facility- or Requester-designed, attach drawings, instructions):
Test Fixture (facility stock, facility fabricated, or requester provided):

Designs/Drawings

We can accept files through a File Transfer Protocol (FTP) site, by e-mail, or via standard mail.

1. E-mail drawings to jsc-cal-ep6-esta@nasa.gov.
2. The Test Director will send an invitation to the NASA FTP site to upload and send files.
3. Mail drawings to National Aeronautics and Space Administration, Attention Martin McClean, Mail Code EP6, Lyndon B. Johnson Space Center, Houston, TX 77058

Instrumentation

Instrumentation (type of instrumentation, number, attach diagram of planned sensor locations):
Instrumentation Provided by Test Requester:

Data Acquisition and Recording

Number of 3-D/6-D Recording Points:	Video Recording (Yes/No):
Sampling Rates:	Photographic Film (Yes/No):
Data File (ASCII/Excel/Trick binary):	Plots (Yes/No):
Other Data Recording:	Special Video Requests:

Other Information

List any other information pertinent to the test:

Test Article Hazard Checklist

A hazard analysis statement is required for any of the following applicable attributes of any of your provided hardware (e.g., test article, support equipment).

Hazard	Y	N	Comments
Mechanical	☐	☐	
Handling (> 40 lb or > 4 ft in any dimension)	☐	☐	
Instability	☐	☐	
Sharp Edges	☐	☐	
Pinch Points	☐	☐	
Exposed Mechanisms (e.g., rotating, reciprocating)	☐	☐	
Pressure Systems	☐	☐	
Stored Energy (e.g., springs, weights, flywheels)	☐	☐	
Ejected Parts, Projectiles	☐	☐	
Electrical	☐	☐	
Voltage (> 50 volts)	☐	☐	
Batteries	☐	☐	
Generation/Storage (e.g., coils, magnets, capacitors)	☐	☐	
Electrostatic Sensitive Devices	☐	☐	

Hazard	Y	N	Comments
Thermal	☐	☐	
Hot Surfaces (> 113 °F, 45 °C)	☐	☐	
Heaters	☐	☐	
Cold Surfaces (< 39 °F, 4 °C)	☐	☐	
Cooling Devices	☐	☐	
Material	☐	☐	
Uncontained Brittle Materials	☐	☐	
Test Environment Incompatibility	☐	☐	
Contained Fluids	☐	☐	
Toxic, Corrosive, Flammable Fluids	☐	☐	
Biohazards	☐	☐	
Miscellaneous	☐	☐	
Noise Level (> 85 dBA)	☐	☐	
Ultrasonic	☐	☐	
Pyrotechnics/Explosives	☐	☐	
Lasers	☐	☐	

Appendix C Instrumentation Provided by Facility

High-Definition Video System

The SDTS High-Definition Video System (HDVS) video provides monitoring and recording of test activities in the SDTS. The HDVS is comprised of two separate camera systems:

- Four Iconix cameras, used primarily to view test articles, can provide detailed, closeup video
- Two Panasonic cameras, with pan, tilt, and zoom capabilities, provide test overview monitoring

Four 17-inch Panasonic monitors provide viewing for the Digital Control System (DCS) Operator and the Test Director. One 52-inch HD monitor provides viewing for test observers. All camera system views are recorded on P2 flash memory modules. Video files can be post processed and archived to portable hard drives. A Global Positioning System (GPS) clock receiver and Inter-Range Instrumentation Group (IRIG) time inserters provide synchronized time information for each camera view recorded.

Cartesian Measurement Devices

Device	Specifications
Optotrak	• 3 and 6 degree-of-freedom, 0.1 mm resolution (0.004 inch) • 4.7 m x 2.6 m x 3.6 m capture envelope • Data rate up to 400 Hz
Leica Laser Tracker	• 6 degree-of-freedom, 0.001 inch static accuracy • 0.002 to 0.010 inch dynamic accuracy • 15 m measurement volume

Appendix D Sample Test Plan

1.0 Introduction

Include a general description of the dynamic test to be performed on the Six-Degree-of-Freedom Dynamic Test System (SDTS)

1.1 Project Overview

Provide a brief description of the project, such as high-level test requirements and a simulation overview. Also include an approximate test timeframe.

1.2 Hardware Overview

Include a high-level description of the hardware to be used for dynamic testing and expected delivery dates.

2.0 Applicable Documents

List all applicable documents, document numbers, and revisions. This list may include stress analyses, safety documentation, and requirements documents.

3.0 Test Objectives

Provide the detailed test objectives. For example, the dynamic test will characterize the translational response of the hardware to various docking parameters. Indicate if the test is for development or flight verification purposes. Include a test matrix, if applicable.

4.0 Responsibilities

4.1 Test Personnel

Indicate key test personnel and responsibilities. The list should include the primary points of contact for test support, such as the test sponsor, test article expert, hardware test engineer, software test engineer, and facility representative.

4.2 Hardware and Support

Provide the responsibility for providing the test articles and support equipment; may include design and fabrication responsibilities. In general, the test customer is usually responsible for providing the test article hardware, hardware documentation, and test matrix. The test customer also may support test integration and coordination. The facility is typically responsible for test integration, hardware handling/lifting and installation, test procedures, data/video collection, and conducting tests.

5.0 Test Description

Provide an overview of the test configuration.

5.1 Test Article Configuration

Describe the test article and the configuration(s) for the test. This may include subsections if several different pieces of hardware are used during the test. Include drawings or photos.

5.2 Facility Configuration

Specify the facility configuration for the test. It may include the position of the rolling structure to accommodate hardware test requirements, location and installation of load cell assemblies, the use of such measurement systems as Optotrak or the Leica laser system, and the use of any video support equipment. It should also include any facility safety limits for position or load aborts.

5.3 Integrated Test Configuration

Provide details about the integrated test configuration. This should include the stack of hardware, from the motion table to the fixed upper structure. A diagram of the test-specific frames of reference should be included in this section.

6.0 Test Operations

Describe the typical test runs that include the initial conditions, the condition for conclusion of a typical test run, and testing limitations. These also can be described in a test matrix form.

7.0 Test Data Requirements

Briefly describe the test data to be measured from the test, and describe the desired format.

8.0 Safety

Address any safety concerns in this section.

Sample Appendix A: Test Details

Include appendices, which provide additional test details that are not included in the main body of the test plan, such as detailed test matrices or test requirements.

Sample Appendix B: Test Schedule

Develop a test schedule. This test schedule template provides a guideline to aid the Test Requester in the estimation of the test schedule. The approved test schedule becomes part of the completed test plan.

ID	Task Name	Duration	Start	Finish
1	**Hardware Dynamic Test**	**122 days**	**Fri 1/1/10**	**Mon 6/21/10**
2				
3	**Test Request Preparations**	**16 days**	**Fri 1/1/10**	**Fri 1/22/10**
4	Review test requirements	10 days	Fri 1/1/10	Thu 1/14/10
5	Determine facility support requirements	5 days	Fri 1/15/10	Thu 1/21/10
6	Provide test request documents to facility	1 day	Fri 1/22/10	Fri 1/22/10
7				
8	**Facility Hardware Preparations**	**20 days**	**Mon 1/25/10**	**Fri 2/19/10**
9	Position rolling assembly	5 days	Mon 1/25/10	Fri 1/29/10
10	Configure measurement systems	10 days	Mon 2/1/10	Fri 2/12/10
11	Install camera systems	5 days	Mon 2/15/10	Fri 2/19/10
12				
13	**Facility Software Preparations**	**13 days**	**Mon 1/25/10**	**Wed 2/10/10**
14	Configure software per test requirements	5 days	Mon 1/25/10	Fri 1/29/10
15	Integrate test simulation	3 days	Mon 2/1/10	Wed 2/3/10
16	Perform abort and limit checkout of software	5 days	Thu 2/4/10	Wed 2/10/10
17				
18	**Documentation Preparation**	**30 days**	**Mon 1/25/10**	**Fri 3/5/10**
19	Prepare test plan	10 days	Mon 1/25/10	Fri 2/5/10
20	Prepare test procedures	5 days	Mon 2/8/10	Fri 2/12/10
21	Prepare hazard analyses	5 days	Mon 2/15/10	Fri 2/19/10
22	Prepare handling/lift documents	5 days	Mon 2/22/10	Fri 2/26/10
23	Prepare Test Readiness Review (TRR) document	5 days	Mon 3/1/10	Fri 3/5/10
24				
25	**Test Hardware Installation**	**14 days**	**Mon 1/25/10**	**Thu 2/11/10**
26	Receive test hardware in facility	1 day	Mon 1/25/10	Mon 1/25/10
27	Install hardware in facility	3 days	Mon 2/1/10	Wed 2/3/10
28	Integrate measurement system hardware with tes	3 days	Thu 2/4/10	Mon 2/8/10
29	Perform integrated safety checkout	3 days	Tue 2/9/10	Thu 2/11/10
30				
31	**Test Readiness Review**	1 day	Mon 3/8/10	Mon 3/8/10
32				
33	**Dynamic Testing**	10 days	Tue 3/9/10	Mon 3/22/10
34				
35	**Post-Test Activities**	**65 days**	**Tue 3/23/10**	**Mon 6/21/10**
36	Remove hardware from facility	3 days	Tue 3/23/10	Thu 3/25/10
37	Prepare test data and video packages	5 days	Tue 3/23/10	Mon 3/29/10
38	Analyze data from test	15 days	Tue 3/30/10	Mon 4/19/10
39	Deliver quick look report	15 days	Tue 4/20/10	Mon 5/10/10
40	Deliver final test report	30 days	Tue 5/11/10	Mon 6/21/10

Appendix E Customer Feedback

SDTS
Session Summary Form
Page 1 of 2

Date:			
Test Requester:		**Organization:**	
SDTS Test Director:		**Program/Project:**	
Scheduled Start Time:		**Session Title:**	

Session Objective:	**Additional Components Used:**
❍ Hardware Development Test ❍ Hardware Verification Test ❍ Demo ❍ Proof-of-Concept Checkout ❍ Other: _____	❍ Simulation ❍ Facility Cameras ❍ Leica/Optotrak Measurement Systems ❍ Audio Communication ❍ Other: _____

Session Summary:

Overall Rating (sponsor only)

When rating your session in the SDTS, please use the following criteria:

10: Testing performed with no problems; required support was excellent
8-9: Minor test problems (down time <10% of session) or support at only acceptable level
6-7: Objectives not completed due to test problems; objectives accomplished but test downtime of >10% of session; unacceptable support
1-5: Session of little or no use due to test problems (hardware or software)

Overall Rating (sponsor only)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Discrepancies Resulting In Loss of Time:

SDTS Session Summary Form ***Page 2 of 2***
Session Notes:
Action Items:

		Preparation Start Time	
TD		Preparation End Time	
		Session Start Time	
		Session End Time	
		Facility Down Time	